

## **AC 2008-1763: ANALYSIS OF TABLET PC BASED LEARNING EXPERIENCES IN FRESHMAN TO JUNIOR LEVEL ENGINEERING COURSES**

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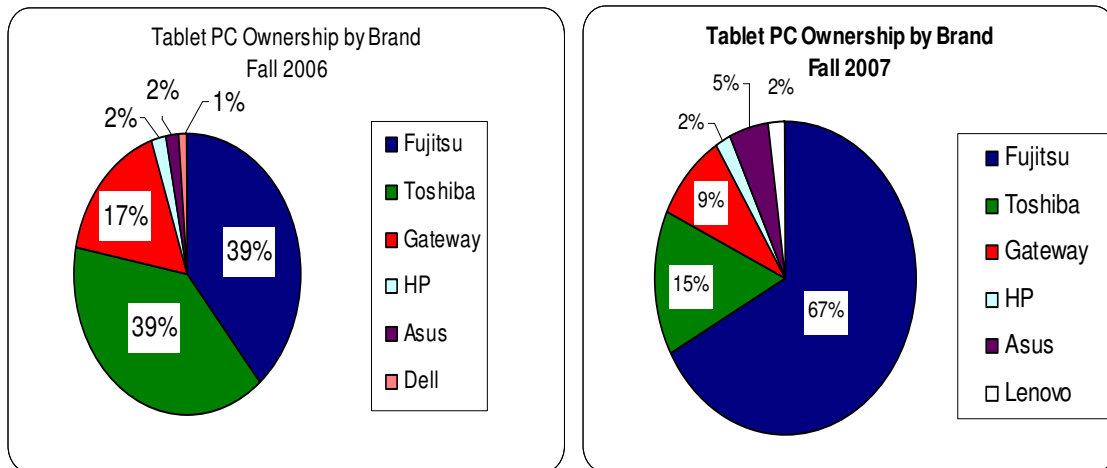
# Analysis of Tablet PC Based Learning Experiences in Freshman to Junior Level Engineering Courses

## Abstract

Virginia Tech announced a Tablet PC initiative for its engineering program in summer 2006. In fall 2006 Tablet based in and out of class activities were implemented in the freshman engineering program. In fall 2007, Tablet based instruction activities were implemented in upper level engineering courses. Typical examples of Tablet based instruction included electronic note taking, use of inking features to review homework solutions, completing skeleton PowerPoint slides, and setting up online collaboration sessions to do group design project and problem solving activities. In addition, the Tablets helped students maintain an electronic log of their individual and group efforts in completing design projects. A major change in 2007 was the incorporation of DyKnow software into instruction. Examples of students' feedback in support of feedback based instruction and assessment data from in-class polling and an end of semester course exit survey of freshmen are presented to discuss the effectiveness of Tablet based instruction. Also, experiences of engineering freshman in fall 2006 and 2007 are compared to show effectiveness of new implementation strategies adopted in fall 2007.

## 1. Introduction

A new Tablet PC computing initiative was announced in summer 2006 for incoming engineering freshmen at the College of Engineering (COE) at Virginia Tech<sup>1</sup>. This initiative made it mandatory for all engineering freshmen (~1300 each year) to own a Tablet PC starting fall 2006. Figure 1 shows the response to an exit survey question (~220 respondents in fall 2006 and ~540 respondents in fall 2007) showing ownership of Tablets by brand. In 1984, the COE was the first public institution in the U.S. to require its entering engineering freshmen to own a personal computer. In 2002, the college moved to a laptop requirement and many of its academic buildings were outfitted to offer wireless communication capabilities.



**Figure 1-** Tablet PC Ownership by Engineering Freshmen at Virginia Tech in fall 2006 and fall 2007 *Note: Dell computers represent laptops.*

The strategies adopted to incorporate Tablets into engineering instruction during the first year (i.e., 2006-07) are discussed in a paper presented at 2007 Annual Conference of ASEE<sup>2</sup>. This paper presents an update on Tablet application in the COE using examples from three fall 2007 engineering courses, one each from freshman, sophomore, and junior level courses, covering freshman engineering, mechanical engineering and civil and environmental engineering programs. Use of DyKnow software is the major change implemented in fall 2007. Assessment results from in-class polling using DyKnow and online course exit surveys, particularly from freshman engineering program, are presented to assess the effectiveness of Tablet PC-based instruction.

## 2. Application of Tablet PC in Freshman Engineering Program

Engineering freshmen at COE are required to pass two freshman engineering courses during their 1-year long freshman engineering (also called General Engineering (GE)) program. The first course is called EngE 1024, "Engineering Exploration" Over the past four years, a number of innovative activities including a sustainable energy design project, mechatronics, world map activity, introduction to systems approach, etc. have been incorporated into EngE 1024. These activities are primarily driven by a new Department-Level Reform (DLR) project from the NSF and a new course delivery format was piloted in spring 2005 with ~210 students<sup>3</sup>. Full implementation of these revisions was successfully executed for the entire freshman engineering class (~1200) in fall 2005<sup>4</sup>. EngE 1024 is a 2-credit course and all engineering freshmen are required to pass the course with a grade of C- or better. Traditionally, this course was taught by EngE faculty using two 50-min lessons per week. The new delivery format includes one 50-minute lesson, taught by faculty in a 150-180 seat classroom, followed by one 90-minute workshop, taught by graduate teaching assistants (referred to as workshop instructors), in a 32-seat classroom each week. The course has now been successfully offered in this new format for six semesters (i.e., spring and fall each year from 2005-07). In fall 2007, ~1300 engineering freshmen were enrolled in the course. There were 8 large lecture sections and 45 workshop sections. Altogether, 5 faculty, 16 graduate students, and 8 undergraduate students were involved in EngE1024 instruction in fall 2007. The lead author co-taught 2 large sections with 300 and 150 students with another colleague. The results presented in this paper for in-class polling in EngE1024 come from these two sections.

### 2.1. Tablet PC Application Strategies

In fall 2007, DyKnow software was implemented in the freshman engineering program. A number of hands-on training activities including presentations by DyKnow experts were organized prior to and during the fall 2007 semester. In addition, use of Microsoft OneNote, a Tablet PC friendly software, was continued to encourage use of digital ink for note taking, homework solution, design project collaboration, etc. The following sections provide details:

2.1.1 DyKnow Applications in EngE1024: DyKnow is a Tablet friendly software developed to make a classroom interactive. The lead author used this software in 2 large lecture sections (~450 freshmen) of EngE 1024 in fall 2007 and continues to use it in the spring 2008 semester. The software has a number of features including sharing slides/panels with the class in a real time, in-

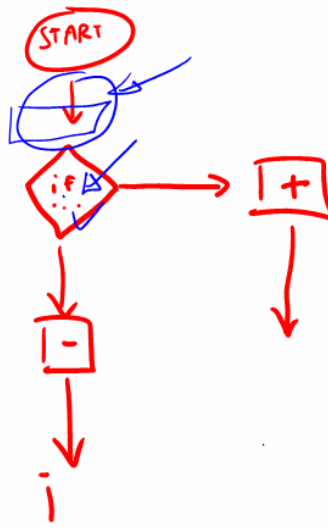
class polling, sharing blank panels with class and anonymous collection of panels from students, demonstration of other applications like programming software using its demonstration mode, providing control to students so that they can share their work with the entire class, etc. DyKnow encourages active learning and discourages passive viewing. In their famous work on classroom assessment techniques<sup>4</sup>, the authors summarize the classroom assessment as follows:

*“Classroom assessment is an ongoing process, perhaps best thought as the creation and maintenance of a classroom feedback loop. By employing a number of simple Classroom Assessment Techniques that are quick and easy to use, teachers get feedback from students on their learning. Faculty then complete the loop by providing students with feedback on the results of the assessment and suggestions for improving learning. To check on their suggestions, faculty use Classroom Assessment again, continuing the feedback loop. As this approach becomes integrated into everyday classroom activities, the communications loop connecting faculty to students - and teaching to learning – becomes more efficient and more effective.”*

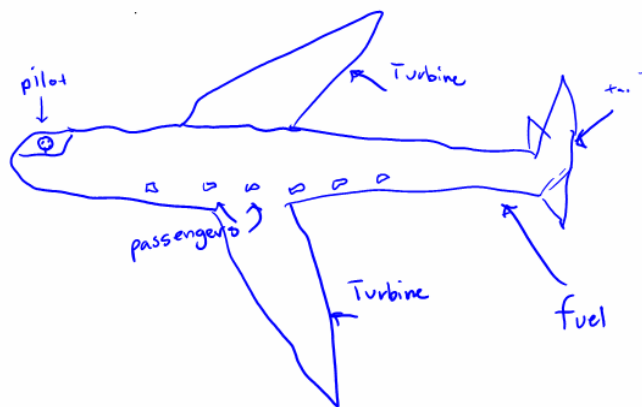
DyKnow is perhaps one of the efficient tools to incorporate above proposed formative assessment into instruction. An example is presented below from a lesson on flowcharting. Traditionally, the lead author used to describe the flowcharting process by developing an incomplete flowchart. This year due to incorporation of DyKnow, the author decided to share a blank panel with all students and asked them to draw the flowchart on their own for a given problem. This problem was discussed before giving this in-class assignment and involved use of sequential and decision control structures. It may be noted that students were assigned to read a flowcharting document before coming to this lesson. The author collected some panels randomly after about 5 minutes and started projecting collected panels on a large screen through a projector. The first panel shared with the class, work submitted by one of the students, is shown in figure 2. Since the panel didn't really show any significant amount of work, the author, feeling that it would embarrass the student, although unknown to class, who submitted the work, quickly changed to another panel that showed a reasonable effort (see figure 3) and discussed various elements of the flowchart that were right or wrong or missing. This was the first day the author experienced the instant advantage of collecting students' work through panels and has implemented this strategy since then to cover a number of other aspects of the course. Students were thoroughly assured that the work is being collected anonymously and their submissions would in no way affect their course grade, etc. Since students don't have a choice of preventing their panel from collection, they are encouraged to participate in the class activity which was found very helpful in a large class. Another interesting observation to be noted here is that a student stopped by the lead author's office after the flowcharting lesson and admitted feeling very good after seeing the first panel, see figure 2 again, and thinking that he's not the only one who's lost in the class. Ever since that discussion, the lead author has started using all panels for discussing students' work or prior knowledge. Figure 4 shows another example of a student's panel that was collected after students were introduced to the concept of a systems approach in engineering. In this case, students were asked to sketch a system and identify its components. Figure 4 shows an airplane system and its components as drawn by a student in class.



**Figure 2-** Student's panel showing in-class flowchart work



**Figure 3-** Student's panel showing in-class flowchart work



**Figure 4-** Airplane System and Its Components – Drawn by a Student

It may be mentioned that DyKnow allows an instructor to share students' panels with all students. In-class polling was done to seek students' feedback on how they felt about their work being shared with peers in class. Here're the results:

*Statement: I like the panels are shared back with the class*  
*Strongly agree (20%), Agree (28%), Neither agree nor disagree (23%), Disagree (4%), Strongly disagree (5%), Invalid data (20%) (Sample size: 235)*

It can be seen that majority of students like seeing other students' work and are possibly finding learning from peers to be a positive experience.

2.1.2 Other Tablet Applications: Like in fall 2006, students were asked to do their homework using OneNote starting the 2<sup>nd</sup> week of the semester. Students were provided with two documents that contained detailed instructions on use of OneNote software. In the lecture, students opened their electronic copies of their solutions on OneNote. The faculty had an official version of the solution on OneNote. While going over the solution, faculty could ink the OneNote file to highlight key parts of the solution. At the same time, students could compare their solutions to the official solution and make their own annotations on their OneNote files. Like in fall 2006, use of Tablets was continued for in-workshop online collaborative problem solving activities, recording design project logs, and receiving feedback on design prototypes in class from peers as discussed in a 2007 ASEE conference paper<sup>2</sup>. Students took advantage of the remote collaboration skills they had developed over the semester. In fact, a group of students used these skills to develop a study guide for the EngE1024 final exam by entering into a remote collaboration session using OneNote and shared their study guide with the lead author.

2.1.3 An Interesting Tablet Application: In fall 2007, the lead author attended an international conference in Coimbra, Portugal and was able to teach his 200+ student class on the campus of this large university in the U.S. from Coimbra, Portugal using the combination of DyKnow and Skype technologies. Engineering freshmen found this 50-min lesson from Europe very interesting and it even motivated them to consider the option to study abroad in the future. Details can be seen in a companion paper in this conference<sup>5</sup>.

## 2.2. Tablet PC Assessment data - Freshman Engineering

As part of an ongoing NSF/DLR project, several formative and summative assessment tools have been implemented in EngE1024. Examples include: use of in-class clickers; student background, learning styles and exit surveys; pre- and post-tests; and focus groups. The following sections summarize the responses students submitted to questions in the exit survey regarding the use of Tablet PCs

2.2.1 Exit Survey Summary: Students were requested to complete an exit survey on a volunteer basis at the end of the fall semester and the survey had a number of Tablet PC related questions. About 220 students responded to the survey in fall 2006 and about 540 students responded in fall 2007. A summary of the responses to each question is given below.

*Question: Did your skills of using the Tablet PC help you in any manner in other courses?(Note, some students omitted this question or submitted invalid responses. Percent calculations were based only on the valid responses received)*

	2006		2007	
	Frequency	Percent	Frequency	Percent
No	128	63.7	266	49.6
Yes	73	36.3	270	50.4
Total	201	100.0	536	100.0

It can be seen that in fall 2006 about 36% of students thought the Tablet PC skills they learned in EngE1024 were helpful in other courses. This number increased to about 50% in fall 2007. Students typically take differential calculus, linear algebra, chemistry, English, and one elective class along with EngE1024 in the fall semester. As far as the authors know, use of the Tablet PCs wasn't emphasized in any other course with the exception of a special section of Chemistry. Although it is unclear exactly why there has been such an increase in Tablet use outside the EngE 1024 coursework, it should be noted that Tablet technology has improved since fall 2006 and this is a possible explanation for the broader usage of tablet PCs.

*Question: As you know, this is the first (second for 2007) year that engineering freshmen were required to purchase a Tablet PC. What in-lecture or in-workshop activities did you think the Tablet PC was useful for? (This was a free response question, the most popular categories of answers are reported below)*

	2006		2007		Comments
	# Reporting	% Reporting	# Reporting	% Reporting	
Note taking	73	37.2	181	33.8	Most of the students used their Tablet PCs to take notes in one way or another whether through inking PowerPoint slides, importing the slides to OneNote, or typing information into the PowerPoint files
Sharing/ group work in shared session	53	27.0	45	8.4	The Tablet PCs were used for shared sessions in the workshop during the problem solving sessions. Most of the students also used shared sessions when meeting with their design project teams outside of the class.
Problem Solving	16	8.2	18	3.4	See above

Homework	12	6.1	42	7.8	This may be a lower than representative number because the homework was not done in class so many students may not have considered this a valid response to this question
Sketching	11	5.6	72	13.4	Sketching was done in class and also for various portions of the group projects and homework.
Reduced paper usage/ No hard copy needed	4	2.0	13	2.4	The ability to use digital ink and to save all notes digitally in one place rather than having multiple paper pages of notes appealed to the students
Flowcharting	3	1.5	9	1.7	The Tablet PCs were used as an aid to teaching flowcharts
DyKnow	N/A	N/A	65	12.1	As was previously mentioned, DyKnow was introduced into the course in 2007 to allow for more interactivity in the lecture.
LabVIEW	N/A	N/A	20	3.7	LabVIEW was introduced into the course in 2007 as a new way to teach freshman engineering students the basics of computer programming.

*Question: If [your Tablet PC Skills helped you in your other courses] please provide some examples of how using the Tablet PC helped you in your other courses (This was a free response question, the most popular categories of answers are reported below)*

	2006		2007		Comments
	# Reporting	% Reporting	# Reporting	% Reporting	
Note taking	65	82.3	240	44.8	The ability to import any document into OneNote or Windows Journal was used by many students not only in their engineering classes but also in chemistry, calculus, and other courses for note taking.
Organization	11	13.9	40	7.5	Several students liked the ability of OneNote to organize their notes like keeping a digital binder with all of their notes in one place
Drawing	5	6.3	13	2.4	Some students found the inking capability of their Tablet PCs useful in classes like chemistry to provide an appropriate drawing to complement their handwritten notes. Some of the students also enrolled in a special section of chemistry which emphasized the use of Tablet PCs in the classroom.
Equations	5	6.3	15	2.8	The ability to use a pen and write down an equation in math classes was put to use by several students. Taking notes using a laptop is often difficult if equations are involved because it can be time consuming to enter equations using a keyboard, but being able to write with the stylus reduced this burden on the student.



Homework	3	3.8	12	2.2	A few students reported using the Tablet PCs to complete their homework for other classes
Reduced paper usage	3	3.8	27	5.0	The ability to use digital ink and to save all notes digitally in one place rather than having multiple paper pages of notes appealed to the students
Group Work/ Collaboration	N/A	N/A	8	1.5	Although it was not mentioned by students in 2006, several students from the fall 2007 offering of the course mentioned using the tablets to collaborate with classmates in other courses.

*Question: The most frustrating aspect of the use of the Tablet PC in this course was: (This was a free response question; the most popular categories of answers are reported below)*

	2006		2007		Comments
	# Reporting	% Reporting	# Reporting	% Reporting	
OneNote	93	47.9	107	20.0	Some students gave specific reasons here while others simply said OneNote itself. The software is obviously not perfect and there are some things Microsoft will probably fix in any future versions of OneNote including correcting auto-formatting problems. It is important to note that in the 2006 offering the students were using OneNote 2003 while in the 2007 offering the students were using OneNote 2007. This may explain the reduction in complaints about the software itself as OneNote 2007 was an improvement over OneNote 2003.
Requirement that homework must be done in OneNote	46	23.7	136	25.4	For a variety of reasons many students would have rather had the choice to do their homework with pencil and paper.
The stylus	17	8.8	17	3.2	Stylus technology varied from manufacturer to manufacturer. Some students liked the models that incorporated an eraser capability at the non-writing end of the stylus. The stylus, particularly on earlier model tablet PCs, did not allow for much precision and often made it difficult to make fine strokes. On some models, the stylus must be calibrated often as many of the Tablet PCs have difficulty in properly placing ink or pointers on the screen in response to the movement of the stylus. The stylus technology does appear to be improving and that can be seen by the reduction in the percent of students who complain about them.

Neatness	9	4.6	19	3.5	Many students found it very difficult to write or draw neatly when using a stylus when compared with traditional pencil and paper. This also posed difficulties in getting some of the Tablet's built in handwriting recognition software to work.
Cost	5	2.6	20	3.7	Some students felt that the additional cost of the Tablet PCs over traditional laptops was not worth it.
No advantage over paper and pencil / laptop.	N/A	N/A	37	6.9	Although this answer was not found much on the 2006 survey, many students in 2007 indicated that they found that most, if not all, of the things the Tablets were used for in the course could have been done comparably or even better on traditional media.
Small screen	N/A	N/A	19	3.5	Tablet PCs typically have screens from 12.1" to 14.1" diagonally. Many students indicated a desire to have a larger work surface on the tablets.
Battery Life	N/A	N/A	13	2.4	Some students wished they could get more time out of a fully charged battery.
Computer freezing/need to reformat	N/A	N/A	16	3.0	Although this issue was not prevalent in the 2006 survey, several students in 2007 indicated that their computer would freeze up periodically and some even indicated that they had to reformat their Tablets.
Need to print OneNote assignments	N/A	N/A	15	2.8	Several students indicated that they would rather submit their OneNote files electronically rather than having to print out a hard copy. The EngE 1024 team is researching the possibility of implementing electronic grading in the course and some other courses at the university are already grading students' work electronically with digital ink.

*Question: The most interesting aspect of the use of the Tablet PC in this course was (This was a free response question; the most popular categories of answers are reported below)*

	2006		2007		Comments
	# Reporting	% Reporting	# Reporting	% Reporting	
Having a stylus to writing/draw on the screen	86	46.7	224	41.8	Many students thought the best feature of the Tablet PC was the ability to write or draw digitally like they could with a normal pen

Shared sessions	28	15.2	43	8.0	Students liked entering into shared sessions to collaborate with their peers
Turning the screen	11	6.0	21	3.9	Some students simply liked the ability of the Tablet PCs screen to rotate
DyKnow	N/A	N/A	59	11.0	Many students liked the various features of DyKnow such as the ability to polls students, collect student drawings or solutions to problems, and the ability to have a record of exactly what the professor was writing on the screen. They also thought the use of DyKnow in the lecture from Portugal was particularly interesting.
Organization	N/A	N/A	25	4.7	Although it was not mentioned as often by students in 2006, several of the 2007 students liked the way OneNote allowed them to organize their notes so they could keep track of information not only for their EngE 1024 class, but other classes as well.

### 3.0 Tablet Application in a ME Sophomore Design Course

The Mechanical Engineering department is the largest engineering major in the COE. All ME sophomores (approximately 300 to 350) own Tablet PCs due to the Tablet initiative of fall 2006. A pilot study was conducted by the 3<sup>rd</sup> author to integrate Tablet PCs technology into two sections of ME 2024 – *Engineering Design and Economics* for enhancing students’ learning experiences. ME 2024 is a required course for all ME students and provides an introduction to product development and design. The course emphasizes team collaboration and technical writing skills and includes topics like project management, mechanical dissections, engineering economics, and ethics. Ten sections of ME2024 are offered each year with class sizes limited to 30 to 36 students. It may be noted that all students participating in this pilot had used a Tablet PC in their freshman year in the EngE1024 course and their experiences are documented in a paper<sup>2</sup>.

#### 3.1 Tablet PC Application Strategies

Students in the pilot sections were divided into teams of three and were assigned a semester design project. They were expected to collaborate in and out of class on project related activities. Teams were given a list of project ideas and were expected to develop a product that is economically feasible and of sufficient technical complexity. Teams were required to meet outside of class, either face-to-face or electronically, for a minimum of two hours per week. In the past, collaborative exercises involved traditional pen and paper mediums with face-to-face interaction. With the introduction of Tablet PCs, students explored online collaboration opportunities using OneNote software. It may be noted that all students participating in the pilot had learned how to do online collaboration using OneNote in their freshman year in the EngE1024 course<sup>[2]</sup> Students utilized these skills to develop online collaboration to discuss design ideas and edited a group’s design sketches electronically. Student teams were required to submit completed work as Vision panels in an instructor driven collaboration session. Panels can be seen at each student’s Tablet PC and the teams present their work to the class at large thus eliminating the need for a class room projector.

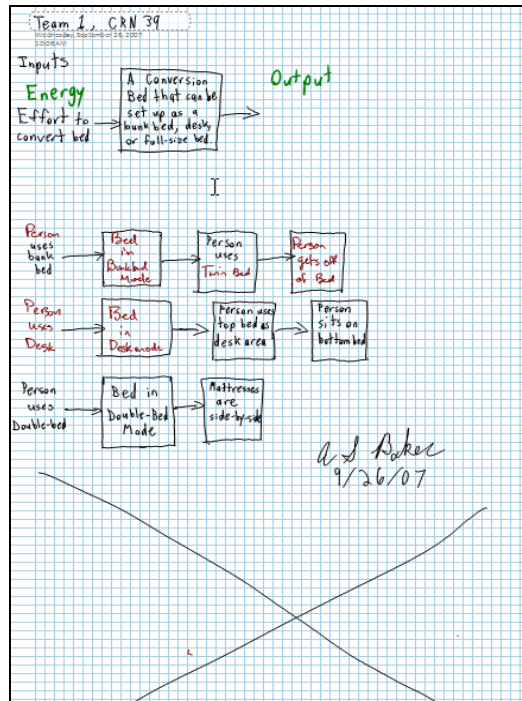
### 3.1.2 Concept Generation and Selection Using Tablet PCs

Concept generation and selection is an important step in product design. Concept generation begins once a team has a general verbal description of the product. Traditionally, the concept generation activity in ME 2024 has used pen and paper and has been an unstructured activity. Teams are expected to give a short presentation of their final design idea at the end. Often, based on 3<sup>rd</sup> author's experience, the class period would end before some teams had the opportunity to present since time was wasted gathering materials and gathering at the front of the class. In the pilot study, this activity is done within OneNote and Vision sessions. Students use tablets to electronically sketch concepts on their own. Then, a OneNote shared session is established allowing members to share ideas electronically. Once a final concept sketch is completed it is sent to the instructor during the Vision session at the end of class. Teams can discuss their concept providing annotation via their stylus to highlight attributes of the design to the entire class while sitting at their table. All teams are now able to share their final ideas with the class because of the time saved using Vision as a presentation tool. Also an electronic archive of the presentation is available to each team and the instructor that can be reviewed and played back later using Vision's *Replay Panel* function. Once panels are submitted to the instructor they are graded and returned.

### 3.1.3 Electronic Engineering Design Logbook

In addition to enhancing team collaboration techniques, students used Tablet PCs to maintain an electronic design logbook. Logbooks must conform to intellectual property rules since entries can be used to establish the date of concept origination in securing U.S. patents<sup>6</sup>. Previously, students used permanently bound paper notebooks. To simulate this electronically, students are required to start a new page within OneNote each day that class meets and sign and date the bottom of that page at the end of that class. The individual page is then converted to a PDF file and stored. The PDF has a date stamp assigned to its property attributes to establish the time and day of file creation. It may be noted that in fall 2006, these students used OneNote to maintain a design logbook for completing a design project in EngE1024 and were provided with two OneNote documents that included required instructions.

In the past when students used paper logbooks they had difficulties understanding the proper methodology of logbook entry. Some students never fully grasped the importance of properly maintaining a logbook with respect to intellectual property law. With the incorporation of Tablet PCs students are given daily instruction in proper logbook entry. During each lecture the instructor (i.e., 3<sup>rd</sup> author) used his Tablet to demonstrate the correct procedure for recording in the design log. It was observed that by the fourth week of the semester a majority of the students correctly created and archived electronic logbook entries. Figure 5 illustrates a typical logbook entry showing the functional decomposition of an automated adjustable bed.



**Figure 5** – Student Engineering Design Logbook Entry Using OneNote<sup>®</sup>

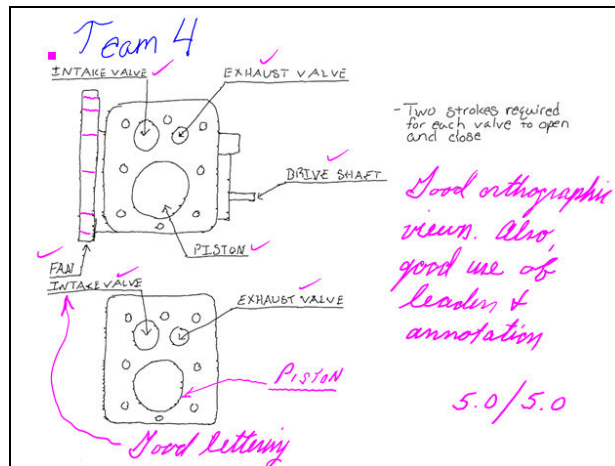
### 3.1.4 Mechanical Dissection with Tablet PCs

During the sixth week of the semester students performed a dissection of a 5 HP Briggs and Stratton lawn mower engine by examining relative motion of the piston, intake valve, and exhaust valve. Students examined major components of the engine such as the crank shaft, connecting rod, and crank rod by constructing detailed sketches of these components, see Figure 6.



**Figures 6** – Students Using Tablet PC's During Mechanical Dissection of an Internal Combustion Engine (ICE)

The dissection activity is facilitated by the use of the Tablet PC as students are asked to draw different components of the engine individually and then combine sketches via a team intranet. This set is compiled into a collection of panels and then submitted electronically to the instructor for grading using Vision. Figure 7 shows a graded team panel indicating the relative location of the piston, fan, drive shaft, and intake/exhaust valves of the dissected ICE.



**Figure 7** – Vision<sup>®</sup> Panel of a Team Sketch of a Briggs and Stratton 5 HP ICE

### 3.1.5 Product Design Review

In order to encourage the use of peer feedback, student design teams are paired during the final few weeks of the semester and are charged to provide constructive feedback on each other's product design. This exercise simulates real world industry practice and allows teams to articulate their own design to peers and to receive constructive criticism. Teams are paired randomly and consist of a total of six students each. A single host is designated to establish a OneNote intranet. The reviewed team then distributes CAD drawing to the critiquing team showing orthographic views of their final product design. Final marked-up CAD Vision panels are then sent back to the reviewed team and to the instructor.

### 3.2 Assessment Data – Mechanical Engineering Application

To study the impact of the new Tablet PC technology on learning in undergraduate engineering courses, a questionnaire was developed in collaboration with experts in education research to measure changes in the learning strategies of the students in ME 2024. The pilot study not only allowed for implementation of new technology but also it allowed for a field test of the measure with pilot study participants (69 students total) to ensure validity. A section of the assessment included questions mirroring the ECAR Research Study 6<sup>7</sup> that examined student skill level with technology using a national sample. The study participants were interested to see if ME 2024 students had the same perceptions about their technology skills as other college students across the country. In addition, questions evaluating student use of the Tablet PC and their opinions about what worked well were included. The online measure also quantifies learning strategies used with the Tablet PC including notetaking, integration of knowledge, critical thinking, and

self-regulation. The results of the field test will drive final questionnaire modifications as well as inform future class activities to optimize the use of the Tablet PC to improve student learning.

Designed to be used twice a semester as a pretest/posttest the instrument will measure change in student learning strategies and levels of collaboration. The instrument allows for future comparison of one class to another. For the spring semester of 2008 two sections of ME 2024 will be offered by the same instructor. One class will fully incorporate Tablet PC technology while the other class will be taught using traditional media. The traditional course will provide an experimental control to enable a comparison of student learning strategies and performance between the two sections. For additional discussion of Tablet PC applications and field test results refer to the referenced paper<sup>8</sup>.

#### 4.0 Tablet Application in a CEE junior level course

In order to expose other faculty members to the potential of Tablet based teaching, the lead author got in touch with his colleague in the CEE department (i.e., 4<sup>th</sup> author) and decided to do two special Tablet based sessions in a junior level CEE course, “Water Resources Engineering CEE3314” in fall 2007. The class included ~50 students. The key topics covered in CEE3314 include: Open channel flow; hydrology; hydraulic modeling; hydraulic machinery and structures and lecture content are supported by laboratory experiments and demonstrations. Two special problems involving design of trapezoidal channels with flexible lining and grass lining were designed for the proposed Tablet sessions. It may be noted that students in CEE3314 didn’t own Tablets. Therefore, 24 Tablets were borrowed from the dean of engineering’s office to implement the Tablet instruction. Students were paired to work on the channel design problems and each pair was given a Tablet. The lead author ran the design sessions while the 3<sup>rd</sup> author went around the class to help answer students’ questions. The authors also had support staff from the dean’s office available in class for helping students with DyKnow questions. The first few minutes during session 1 were consumed in explaining the basics of Tablet PCs and DyKnow software.

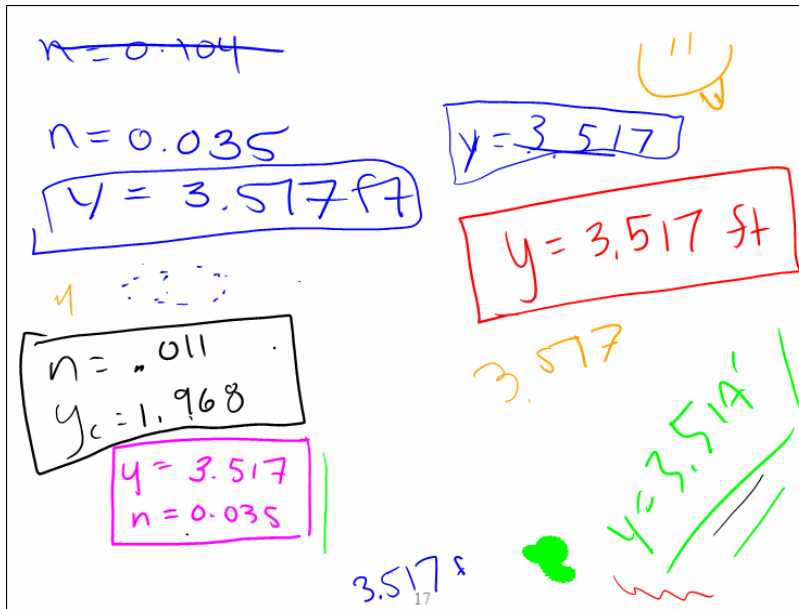
Here’s a stepwise procedure that was adopted to implement the channel design session using Tablets. First, a blank panel was shared with each pair and they were provided with 3-4 questions that had them think about the design problem that followed. Here are some examples. What do we mean by “Flexible Lined” Channel? What materials qualify as “flexible”? When would you want to use a “flexible lined channel”? The panels were collected after a few minutes from each group. See Figure 8 for an example response. Student responses were discussed to clarify doubts and then students started the design work. They had to pick various design related information. For example, Manning’s roughness coefficient, side slope for the channel, and had to report channel depth calculation using a shared panel. For this purpose the instructor shared a panel with each group using DyKnow and asked them to report their design depth after completing computations. Figure 9 shows results reported by various groups. As can be seen, all groups reported a design depth of 3.5’. These depth values appeared on every group’s screen over a period of ~5 minutes and provided students with the opportunity to observe other students’ progress and results. Once a few steps of the design were completed, the instructor shared another panel with students and asked them to list all the steps that are required to complete the design problem and mark the steps which have been completed or are yet to be completed. Figure 10 shows an example panel submitted by a group. This provided an opportunity for all to

review the entire design exercise and see where each group stands in terms of their progress in completing the in-class design problem. During the second session, a similar design problem was done except students had to consider grass lining. At the end of the session students were asked to share sketches of their two designs and describe key differences in design parameters including possible reasons. This was done by first sharing a blank panel with each group and then collecting their panels with sketches. Figure 11 shows an example of two designs submitted by a student. Students at the end were asked about their impressions of DyKnow using the built-in polling feature and ~75% of students expressed their satisfaction with the tablet sessions. It may be noted again that these students had not used Tablets before and learned applications like DyKnow in two 50-min class sessions.

Answers?

1. channels lined w/ gravel/rip rap.
2. rip/rap, gravel, sand, plastic
3. drainage w/ filtering, anywhere where

**Figure 8-** A student’s feedback to pre-design questions

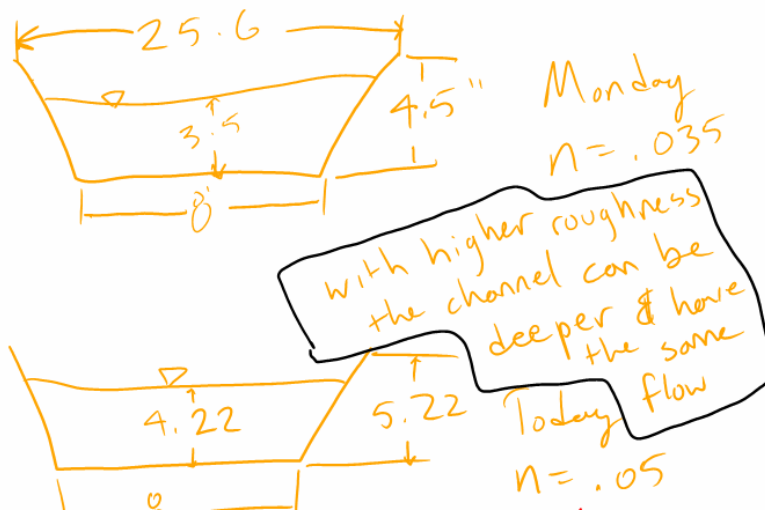


**Figure 9-** Response sharing from various design groups on depth of channel



- Step 1. assume depth
2. determine retardant class
3. calc.  $n$  initial
4. calc  $AR^{2/3}$
5. compute new  $y$
6. Repeat 3-5
- \* 7 recompute  $y$
- \* 8 find  $T_{allow}$
- \* 9 calc  $T_{design}$ , ok?
- \* to do \*10 compute  $T_{width}$

**Figure 10-** Design steps (completed and yet to be completed) – feedback from a student



**Figure 11-** Comparison of two designs – panel from a student

## 5.0. Conclusion and Future work

The use of Tablet PCs in engineering instruction is gaining momentum in the COE. Case studies from three courses indicate that students will continue to appreciate the potential of Tablet technology if they keep using it for enhancing learning experiences in various courses. It is clear from data collected in freshman year exit surveys in fall 2006 and 2007 that a significantly higher proportion of students find Tablet PCs useful in courses which do not explicitly require the use of the Tablet PC. It seems that the Tablet PC hardware is improving in reliability and OneNote has improved from the 2003 version to the 2007 version. There is still a significant room for improvement in both hardware and software for the Tablet PCs. Tablets combined with software like DyKnow definitely have the potential to improve teaching pedagogy in engineering. In spring 2008, the use of DyKnow for enhancing collaborative problem solving skills in EngE 1024 is being piloted. The lead author has submitted a Tablet Buddy proposal to the dean's office which includes combining a faculty member familiar with the use of Tablets with another faculty in the COE who hasn't used Tablets so far in order to promote the use of Tablets in various courses. Recently, a faculty teaching large statics classes has expressed interest in using Tablets and DyKnow in his instruction and visited the lead author's DyKnow class in fall 2007. It may, however, be noted that all classrooms are not fully equipped to make use of all Tablet features at the time of this writing.

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